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Dental orthopantomogram biometrics system for human identification

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ABSTRACT

Fingerprinting is the most widely accepted method of identification of people. But in cases of disfigured, decomposed, burnt or fragmented bodies, it is of limited value. Teeth and dental restorations on the other hand are extremely resistant to destruction by fire. They retain a number of their original characteristics, which are often unique and hence offer a possibility of rather accurate and legally acceptable identification of such remains. This study was undertaken to evaluate the utility of orthopantomography for human identification and propose a coding system for orthopantomogram (OPG), which can be utilized as an identification tool in forensic sciences.

1. Introduction

Fingerprinting is the most accurate method of identification of people. But in cases of disfigured, decomposed, burnt or fragmented bodies, it is of limited value. Teeth and dental restorations on the other hand are extremely resistant to destruction by fire. They retain a number of their original characteristics, which are often unique and hence offer a possibility of rather accurate and legally acceptable identification of such remains.[1] It is recognized that reliable objective evidence is provided by medical and dental radiographs in forensic identification. This depends on the observation and comparison of anatomical and artificial structures recorded in both ante-mortem and post-mortem radiographs, and which can be regarded as unequivocal evidence.[2] Martin-de-Las-Heras et al. in their scientific paper on utility of dental patterns in forensic dentistry have emphasized and concluded that conditional diversity value derived from dental patterns is a potentially valuable tool with broad applicability for human identification.[3]

Usually conventional and digital radiographs are stored in an image format, which remains difficult to transmit via electronic media due to enormous file size. Image format limits comparison between two subjects in electronic systems, digital code is an easier format for electronic transmission and inter-subjective comparisons. This study was undertaken to evaluate the utility of orthopantomography for human identification and propose a coding system for orthopantomogram (OPG), which can be utilized as an identification tool in forensic sciences.

2. Materials and methods

Thirty orthopantomograms were randomly selected from the patient database stored at the Department of Oral and Maxillofacial Radiology, Peoples Dental Academy, Bhopal, India. All the 30 radiographs had been taken in a Planmeca Proline XC OPG machine with an 18 s exposure and with exposure parameters ranging from 4 to 12 mA and from 60 to 80 kVp. Dental patterns were

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identified and converted into a consistent set of codes by a well-trained maxillofacial radiologist following the criteria described as under.

3. Coding the dentition in an orthopantomogram

The entire dentition was divided into four quadrants on an OPG as per the FDI World Dental Federation notation (Table 1). Dentition/tooth was coded according to the criteria described by Lee et al. (Table 2).[4] For assessment of the roots of the tooth, a central mid-sagittal line (MS) was drawn between upper and lower central incisors on the OPG to be coded. A long axis (LA) to each tooth root was drawn from the root apex to the mid point on the pulp chamber. LA of the each tooth root(s) was classified as medial (M) deflection, distal (D) deflection or no deflection (S) from the MS. The missing root was denoted as 'X'. Each tooth in all the four quadrants were denoted/coded with four characters: First and second, the two digit tooth number; Third, dentition/tooth code of Lee et al.; Fourth, LA of the each tooth root(s) as M/D/S. In case of multi-rooted tooth, if the roots were radiographically fused, it was considered same as in cases of single rooted tooth but if radiographically there was more than one root, the closest root to MS was considered for the coding (Fig. 1, Table 3). The codes generated were different for all 30 selected OPGs.

Table 1
FDI World Dental Federation notation for human dentition.

FDI Notation															
Permanent teeth															
upper right								upper left							
18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
lower right								lower left							
Deciduous teeth															
upper right								upper left							
			55	54	53	52	51	61	62	63	64	65			
			85	84	83	82	81	71	72	73	74	75			
lower right								lower left							

Table 2
Code for dentition/tooth in orthopantomograms as described by Lee et al.[4]

Code for dentition/tooth in orthopantomograms
V (Virgin tooth): No evidence of dental disease, treatment or anatomical abnormality
X (Missing tooth): Extracted or congenital missing tooth
I (Impacted tooth): Unerupted or impacted tooth
D (Defect): Defect by dental caries, tooth fracture or fallen out fillings
R (Residual root): Remained root due to severe dental caries
T (Root canal treatment): Root canal filled tooth by endodontic treatment
F (Filling): Filled tooth
P (Prosthesis): Tooth with crowns

4. Generating the QR code for each quadrant

For easy transmission, comparison and storage of the orthopantomogram code generated were digitalized to a quick response (QR) code. Four QR codes were generated for a single orthopantomogram each corresponding to an individual quadrant (Fig. 2). The QR codes for the individual quadrants were generated with the data obtained by manually coding orthopantomograms, as described above, using an online QR generator: http://www.barcodesinc.com/generator/qr/ (BarcodesInc, Chicago). All the QR codes generated for 30 OPGs were cross-checked for their accuracy using a Barcode Scanner (ZXing Team) installed on a hand held android device (Samsung N7000) running Android 2.3.6 gingerbread.

5. Observer identification percentage

All 30 OPGs were coded and blinded for identification. Two blinded observers (qualified medical transcription personals) were explained the procedure to decode the OPGs following the manual coding system described. Both observers matched/decoded 28 OPGs (93.33%) out of 30. The two OPGs mismatched were different for both the observers.

6. Results

All thirty OPGs selected for the study were easily coded following the described protocol by a qualified maxillofacial

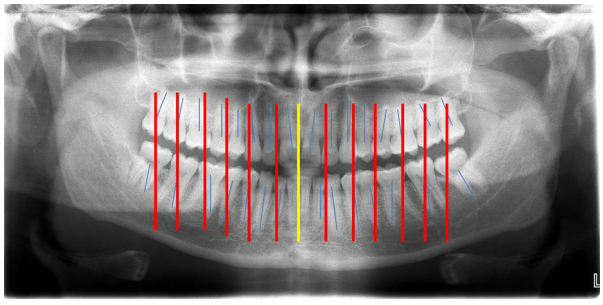

Fig. 1. OPG showing a central mid-sagittal line (MS, yellow) and long axis (LA) to each tooth root was drawn from the root apex to the mid point on the pulp chamber (blue). Parallel lines to MS for comparison with individual root LA is shown in red. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 3
Manual coding following the described protocol for Fig. 1.

Quadrant	Code
1st	11VD12VS13VD14VS15VS16VS17VM18VM
2nd	21VD22VS23VS24VS25VD26VM27VM28VM
3rd	31VM32VS33VD34VD35VD36VS37VD38VD
4th	41VS42VD43VD44VD45VD46VS47VD48VD

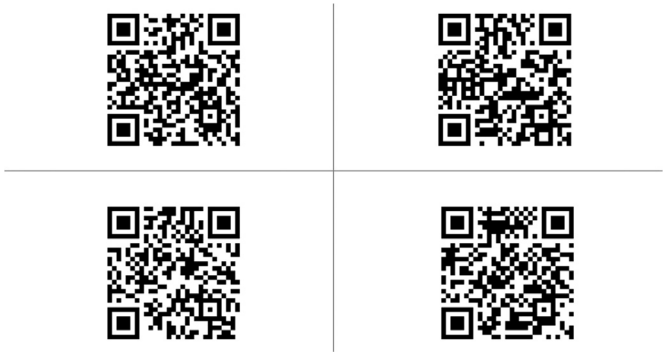

Fig. 2. Quick response (QR) codes for the four quadrants, scannable with a barcode/QR code scanner for the OPG shown in Fig. 1.

radiologist. The manual coding done for the OPGs was different for all the 30 radiographs indicative of 100% diversity of dental patterns in the selected orthopantomograms. The average time taken for coding of all the four quadrants of an OPG was 3 min 45 s (±30 s). The accuracy of decoding OPGs was 93.33%. The average file size of a digital high quality OPG image was 4.26 MB (Bitmap image) where as the QR code image for all four quadrants occupied 88.7 kB (JPEG image).

7. Discussion

Investigations of jaws and teeth, the most well preserved parts of the human body, have been proven a basic and valuable method in human identification.[5] This study utilizes OPGs as orthopantomographs provide a complete view of both jaws and teeth in one image and offer advantages in terms of dental record keeping.[4] Further interpreting and comparing OPGs would require a skilled maxillofacial radiologist, instead coded forms can be utilized by any trained forensic or data management personal. Coded formats can even be utilized by electronic systems or computer programs for comparisons. Coded formats also have an advantage of a lesser file size when compared to the image formats.

The use of orthopantomography in identification has been recommended because it helps visualize structures of the jaws and related areas on a single radiograph.[6] Keeping this in mind, dental patterns in the orthopantomography described by Lee et al. were included for this study. Lee's study was based on 300 orthopantomograms classifying dental patterns into eight types which were commonly observed in dental radiography and converted into a consistent set of codes by a well-trained forensic odontologist.[4] Our study further included root angulations, which may find its application when tooth crown is fractured or mutilated if the victim is involved in trauma or disasters. In the study by Lee et al. diversity of the dental patterns in the orthopantomogram data was found to be 99.92% for full dentition and the diversity in mandible and maxilla was 99.28% and 98.22%, respectively. In our study diversity in dental patterns on orthopantomography was 100%, this may be due to a smaller sample size.

QR codes are two dimensional matrix barcode which can store data within the code and may find its application in forensic data transmission in both electronic and print media. Use of such universally accepted coding system will allow exchange of information in a form not subject to linguistic barriers.[4,7] QR codes can be easily interpreted using hand held mobile devices and barcode scanners.

Although observer identification percentage was high at 93.33% (28 out of 30), errors in identification remained in drawing the root lines in maxillary molars (LA). Maxillary molars are multi-rooted teeth with some degree of superimposition in the radiographic image, which may render difficulty in identifying the root apex of the mesio-buccal root.[8] This may be considered as one of the limitation in the applications of this study.

We may conclude with reasonable certainty that the advantages of the results of this study are that the method involving coded digital radiographs can be easily stored in a central archive, retrieved and transmitted to mass casualty sites,[1] data transmissions become many times easier due to the negligible file size of the digital codes. Records of the dental hard tissues from a coded panoramic radiograph could serve as an ante-mortem and post-mortem comparative tool for forensic identification of an individual.

8. Conclusion

Dental hard tissues serve as an excellent ante-mortem and post-mortem record for forensic sciences. The diversity of dental patterns in orthopantomography can serve as an important tool for forensic identification. A simplified and widely accepted coding system, like QR codes, will make the readability of these records easier among non-maxillofacial radiologists or non-medical personal, who are the people usually involved in such an identification process.

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Conflict of interest
None declared.

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